WHAT IS CLAIMED IS:

1.   A method for predicting impact performance of an article constructed of a painted material, the method comprising:

applying physical properties of the material to a constitutive model;

performing biaxial property tests on painted samples of the material shaped according to test geometries and determining the failure mode as a function of strain rate and temperature;

performing finite element simulation analysis on the test geometries using the constitutive model;

determining maximum principal stress levels from the finite element simulation analysis corresponding to experimental failure displacements obtained from the biaxial property tests that failed in a brittle failure mode;

applying the maximum principal stress levels and the constitutive model to finite element simulation analysis of the article.

2.   The method of claim 1, wherein said constitutive model characterizes deformation behavior of the material with respect to strain rate, temperature, and stress behavior.

3.   The method of claim 1, wherein said biaxial property tests are performed at a practical range of service conditions of the article.

4.   The method of claim 1, wherein said applying includes:

determining maximum principal stress levels for one or more strain rates; and

averaging said maximum principal stress levels at each of said one or more strain rates.

5.   The method of claim 1, wherein said applying includes:

determining maximum principal stress levels for one or more temperatures; and

averaging said maximum principal stress levels at each of said one or more temperatures.

6.   The method of claim 1, wherein said applying includes:

determining maximum principal stress levels for one or more strain rates; and

determining the lower bound of said maximum principal stress levels at each of said one or more strain rates.

7.   The method of claim 1, wherein said applying includes:

determining maximum principal stress levels for one or more temperatures; and

determining the lower bound of said maximum principal stress levels at each of said one or more temperatures.

8.   The method of claim 1, further including:

validating the constitutive model by comparing analytical load-displacement response from the finite element simulation analysis using the constitutive model with the experimental load-displacement results obtained from said biaxial property test.

9. The method of claim 1, wherein the constitutive model is represented by the relationship:

$$\dot{\bar{\varepsilon}}_{pl} = \dot{\varepsilon}_0 \exp[A(T)\{\sigma - S(\bar{\varepsilon}_{pl})\}] \times \exp[-p\alpha A(T)]$$

wherein:

$\dot{\bar{\varepsilon}}_{pl}$ is the equivalent plastic strain rate;

$\bar{\varepsilon}_{pl}$ is the equivalent plastic strain;

A, $\dot{\varepsilon}_0$ are rate dependent yield stress parameters which depend on temperature (T);

σ is the equivalent von Mises stress;

S is internal resistance stress (post yield behavior); and

α is pressure dependent yield stress parameter.

10. The method of claim 1, further including:

determining the physical properties of the material using a tension test and a compression test.

11. The method of claim 10, wherein said determining the physical properties includes:

comparing tensile and compressive yield stresses at the same rate to determine a pressure dependent material parameter; and

inputting said pressure dependent material parameter into the constitutive model.

12.   The method of claim 1, wherein said applying includes:

inputting the maximum principal stress levels and the constitutive model into a user subroutine, the user subroutine setting a stiffness matrix for an element in a finite element module to zero when the stress level in the element is calculated to exceed the maximum principal stress levels..

13.   The method of claim 1, wherein said performing biaxial property tests includes applying biaxial property tests on an unpainted side of a first test sample, and applying biaxial property tests on a painted side of a second test sample; and

wherein said determining failure criteria of the material includes:

obtaining peak maximum principal stress values corresponding to the experimental failure displacements, the peak maximum principal stress values being determined from the finite element simulation analysis, and the experimental failure displacements being determined from the biaxial property tests performed on the first and second test samples,

checking consistency across the maximum principal stress values obtained using the experimental failure displacements determined from the biaxial property tests performed on the first and second test samples, and

determining the maximum principal stress values as a function of at least one of strain rate and temperature.

14.   A method for predicting impact properties of an article, wherein the method incorporates biaxial property tests determined under a practical range of service conditions in finite element simulations of test geometries to obtain brittle failure criteria.

15. A method for determining failure criteria wherein the method comprises:

obtaining deformation model parameters;

performing property tests under varying rates and temperatures and recording load displacements;

determining failure displacements for test conditions employed in said performing property tests;

using deformation model parameters in a finite element input deck and post yield data in a user material subroutine;

selecting analysis displacement and time to approximate test failure displacement and displacement rate; and

obtaining maximum principal stress for brittle failure.

16.   A system for predicting impact performance of an article constructed of a painted material, the system comprising:

a mechanical testing machine configured to perform biaxial property tests on samples of the material shaped according to a test geometry;

an applications server coupled to said mechanical testing machine, said applications server being configured to:

apply physical properties of the material to a constitutive model;

perform finite element simulation analysis on the test geometry using the constitutive model;

receive data from the performance of the biaxial property tests;

determine brittle failure criteria of the material using the data from the biaxial property tests and the finite element simulation analysis on the test geometry; and

apply the brittle failure criteria and the constitutive model to finite element simulation analysis of the article.

17.   The system of claim 16, wherein said constitutive model characterizes deformation behavior of the material with respect to strain rate, temperature, and stress behavior.

18.   The system of claim 16, wherein said biaxial property tests are performed at a practical range of service conditions of the article.

19.   The system of claim 16, wherein said applications server is further configured to:

validate the constitutive model by comparing analytical load-displacement response from the finite element simulation analysis using the constitutive model with the experimental load-displacement results obtained from said biaxial property test.

20. The system of claim 16, wherein the constitutive model is represented by the relationship:

$$\dot{\bar{\varepsilon}}_{pl} = \dot{\varepsilon}_0 \exp[A(T)\{\sigma - S(\bar{\varepsilon}_{pl})\}] \times \exp[-p\alpha A(T)]$$

wherein:

$\dot{\bar{\varepsilon}}_{pl}$ is the equivalent plastic strain rate;

$\bar{\varepsilon}_{pl}$ is the equivalent plastic strain;

A, $\dot{\varepsilon}_0$ are rate dependent yield stress parameters which depend on temperature (T);

σ is the equivalent von Mises stress;

S is internal resistance stress (post yield behavior); and

α is pressure dependent yield stress parameter.

21. The system of claim 16, wherein said mechanical testing machine performs a tension test and a compression test on the material, and said application server determines the physical properties of the material using data from the tension and compression tests.

22. The system of claim 21, wherein said mechanical testing machine compares tensile and compressive yield stresses at the same rate to determine a pressure dependent material parameter; and inputs said pressure dependent material parameter into the constitutive model.

23. A storage medium encoded with machine-readable computer program code for predicting impact performance of an article constructed of a painted material, the storage medium including instructions for causing a computer to implement a method comprising:

applying physical properties of the material to a constitutive model;

performing biaxial property tests on painted samples of the material shaped according to test geometries and determining the failure mode as a function of strain rate and temperature;

performing finite element simulation analysis on the test geometries using the constitutive model;

determining maximum principal stress levels from the finite element simulation analysis corresponding to experimental failure displacements obtained from the biaxial property tests that failed in a brittle failure mode;

applying the maximum principal stress levels and the constitutive model to finite element simulation analysis of the article.

24. The storage medium of claim 23, wherein said constitutive model characterizes deformation behavior of the material with respect to strain rate, temperature, and stress behavior.

25. The storage medium of claim 23, wherein said biaxial property tests are performed at a practical range of service conditions of the article.

26. The storage medium of claim 23, wherein the failure criteria includes ductile and brittle failure criteria.

27.   The storage medium of claim 23, further including instructions for causing a computer to implement:

validating the constitutive model by comparing analytical load-displacement response from the finite element simulation analysis using the constitutive model with the experimental load-displacement results obtained from said biaxial property test.

28.   The storage medium of claim 23, wherein the constitutive model is represented by the relationship:

$$\dot{\overline{\varepsilon}}_{pl} = \dot{\varepsilon}_0 \exp[A(T)\{\sigma - S(\overline{\varepsilon}_{pl})\}] \times \exp[-p\alpha A(T)]$$

wherein:

$\dot{\overline{\varepsilon}}_{pl}$ is the equivalent plastic strain rate;

$\overline{\varepsilon}_{pl}$ is the equivalent plastic strain;

A, $\dot{\varepsilon}_0$ are rate dependent yield stress parameters which depend on temperature (T);

σ is the equivalent von Mises stress;

S is internal resistance stress (post yield behavior); and

α is pressure dependent yield stress parameter.

29.   The storage medium of claim 23 further including instructions for causing a computer to implement:

determining the physical properties of the material using a tension test and a compression test.

30.   The storage medium of claim 29, wherein said determining the physical properties includes:

comparing tensile and compressive yield stresses at the same rate to determine a pressure dependent material parameter; and

inputting said pressure dependent material parameter into the constitutive model.